PB 206 724
NTID300.11

THE SOCIAL IMPACT OF NOISE

DECEMBER 31, 1971

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield, Va. 22151

U.S. Environmental Protection Agency
Washington, D.C. 20460

NTID300.11

THE SOCIAL IMPACT OF NOISE

DECEMBER 31, 1971

Prepared by

THE NATIONAL BUREAU OF STANDARDS
under
INTERAGENCY AGREEMENT

with

U.S. Environmental Protection Agency
Office of Noise Abatement and Control
Washington, D.C. 20460

This report has been approved for general availability. The contents of this report reflect the views of NBS, which is responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policy of EPA. This report does not constitute a standard, specification, or regulation.

BLANK PAGE

Noise has a number of characteristics in common with other environmental pollutants. It effects are biological, psychological and sociological. Another common feature shared is that it is extremely difficult to establish simple causal relationships between the pollutant and its consequences. The data associated with the effects of noise cover a broad range of conditions. At one extreme, a loud explosion can result in the destruction of the sensory receptors of the ears and consequently, total deafness. The other end of this continuum is represented by temporary physiological changes which often accompany exposure to "moderate" levels of noise. As might be anticipated, most of the available findings fall between these extremes and at best, only probabilistic, rather than causal, statements can be made concerning effects. To complicate the situation even further, the adequacy of the data base differs from discipline to discipline. Physiological consequences are better understood than psychological ones, and both disciplines are further advanced than sociological science with respect to noise effects.

Although many of the findings related to noise lend themselves to a variety of interpretations, there is general agreement on a number of factors:

1. Noises of sufficient intensity <u>have caused</u> irreversible hearing damage.

2. Noises <u>have</u> produced physiological changes in humans and animals that in many instances have <u>not</u> resulted in adaptation.

3. The effects of noise are <u>cumulative</u> and, therefore, the levels and durations of noise exposure must be taken into account in any overall evaluation. The recognition of this fact has been translated into legislation specifying limits of total permissible noise exposure in industrial settings.

4. Noises can interfere with speech and other communication.

5. Noise can be a major source of annoyance by disturbing sleep, rest, and relaxation.

6. When community noise levels have reached sufficient intensity, social action has occurred to reduce their effects. This has often taken the form of creating new organizations (or using existing ones) to press for regulation by means of laws, ordinances and standards.

The Social Impact of Noise:
A Survey of Medical, Psychological, and Social Consequences

Introduction

The World Health Organization defines health as a state of physical, mental, and social well being and not merely the absence of disease or infirmity. Using this definition it is evident that noise can be considered as having an important influence on the health of man. Because of its pervasive influence in all settings, activities and walks of life it has been often cited as a major source of annoyance as well as a threat to physical and mental health. For most people the usual consequences of noise are associated with interference with listening to speech or other sounds, distraction at home and on the job, disturbance of rest and sleep, and disruption of recreational pursuits. All of the foregoing can be considered components of the quality of life.

In dealing with the social impact of noise, this report is divided into several sections:

1. Overview
2. Extent of problem -- Changing Scope of Problem
3. Effects of Noise -- medical, psychological, social.
   - 3.1 Medical
   - 3.2 Psychological
   - 3.3 Social

1. Overview

Although there is some controversy about the rate of growth of noise levels in urban areas, primarily due to a lack of substantiated trend data, there is general agreement with the statement in the recent publication "The Noise Around Us" (1)*; that the average urban noise levels are continuing to climb and now constitute a serious detraction from the quality of life in many cities. The report also states that "while urban noise may have been tolerable in the past, the increasing utilization of technology is resulting in a steady increase in the number of noise sources. The noise problem is compounded because urbanization and the increased concentration of population bring about more exposure to the ordinary sounds of living". The Executive Director of the American Public Health Association, Charles Johnson, indicated at the EPA Hearings (2) that "roughly one hundred and thirty million people live in metropolitan areas subject to the noises arising from transportation or construction projects, crowding and congestion and widespread manufacturing activities".

*Figures in parenthesis indicate the literature references at the end of this report.

2. Extent of Problem -- Changing Scope of Problem

In a sense the noise problem of "today" is both qualitatively and quantitatively different from what it was "yesterday". Noise can no longer be thought of as a rather localized and confined problem. For example large cities have "always" been associated with noise since by definition they were the centers of activities having industries, transportation, power facilities and large populations. A report by Congress in 1937 (3) stated:

"The large city and especially its central business district is so characteristically a place of noise that a sudden wave of silence frequently proves to be oppressive to the urbanite for he is accustomed to distracting sounds of all kinds. Screeching brakes, screaming trolley cars, rumbling trucks, rasping auto horns, barking street vendors, shouting newsboys, scolding traffic whistles, rumbling elevated trains, rapping pneumatic hammers, open cut-outs, and now advertising sound trucks and aircraft with radio amplifiers, when added together, constitute a general din for which it would be difficult to find a precedent in the history of cities."

After noting the intense sound levels produced by subway and elevated trains used in several cities, the Wyle Laboratory EPA Report (4) indicates that these systems carry 4.3 million commuters daily. The rail transit system in a number of instances is operated in conjunction with trolley lines which serve 182 million passengers annually. When one considers that these transportation facilities are located so as to be convenient for commuters and therefore adjacent to high density residential areas, the overall noise impact on the community can be better understood.

This same report further indicates that transportation noise is the major cause of the escalation of the noise problem in the country. It indicates that nine million people living in homes covering an area of 2000 square miles are currently being exposed to aircraft and highway noise levels said to be incompatible with residential living. A recent report by the National Academy of Sciences (5) indicates that in the vicinity of Kennedy Airport 700,000 live under these conditions and there are 220 schools in the same area which are attended by 280,000 pupils. Although these findings are cause for concern, the trend is even more disturbing. For example, a report (6) concerned with noise at Logan Airport, Boston, Massachusetts indicates the following:

Estimated Impact of Noise at Logan Airport

	1967	1975
Estimate of operations-Miles	90,000	280,000
Area "not compatible with residential living" (square miles)	25	80
People	177,000	556,000
Schools	93	272
Hospital Beds	1,391	3,158

These statistics partially reflect the fact that jet aircraft have almost totally replaced those powered by piston engines. Also, the "jets" are from 10 to 20 dB "louder" than their predecessors, have more power and produce noise which is judged more annoying than piston engines producing an equally intense sound.

People living in the inner cities have often considered noise as being a necessary evil to be borne in exchange for the convenience of living either near their places of work or in proximity to public transportation routes which can be used for commuting. However, the urban sprawl which has accelerated greatly since World War II has resulted in a significant expansion of the area and people affected by urban noises.

However, it appears that the most dramatic change in the scope of the noise problem has occurred in areas outside of our cities. The accelerated growth of surburban areas combined with the mobility of the population has brought about this circumstance. Primarily by changes in land use patterns, there has been a systematic invasion of noises outward from the city into the quietest areas of the nation. Surburban areas have been converted to urban, farm to suburban, residential to industrial, etc. For example, construction of an industrial plant results in a considerable change in outdoor noise levels because of many factors associated with new industry. Road, rail lines and/or airport facilities are needed, new workers may have to be accommodated and community services increased. All of these activities profoundly affect the noise environment in at least two phases - - during construction and use. The Bolt Beranek and Newman report for EPA (7) indicates that construction noises alone affect approximately 30 million people a year. In the case of major construction activities (highways, industrial plants) the process is a prolonged one. The growth in "general aviation", typified by private and business aircraft, has led to the construction of small airports in many suburban and rural areas. This has also served to introduce a major noise source into many residential communities.

Recreational areas have also changed for the worse with respect to noise intrusions. As more people have the time, inclination and resources to travel, the more remote parts of our country are attracting large numbers of tourists. This desire for travel has resulted in roads and airfields which penetrate formerly remote regions. When these formerly wilderness areas become relatively accessible, tourists bring with them their powerful machines. Areas which formerly were characterized by sounds of nature now accommodate power boats, snowmobiles, minibikes, motorcycles, radios and television sets.

In a sense there are two distinctive types of noise disruptions. One, characterized by high ambient levels, is found in the inner cities and near major transportation routes, and the other, basically single event noise, intrudes into suburban and rural areas. Both have in common the capability to reduce our enjoyment of the outdoors whether at home or during recreational pursuits.

Thus far, the noise sources considered have been those outside the home. However, man has become very much dependent on labor saving devices and most of them are centered in and around the home. These machines, in common with others, have become more prevalent and more powerful with the passage of time. In some instances, the noises produced are on the verge of becoming a serious health problem as well as being a major source of irritation.

The following table provides a general summary of the growth of noise sources since 1950:

Growth in Noise Sources*

(M = Million, TH = Thousand)

Year:	1950	1960	1970
Population (M) :	151	181	204
Transportation Vehicles			
Cars, Buses, Trucks (M)	49.2	73.9	106.3
Motorcycles (M)	0.45	0.51	3.0
Powered Boats (M)	2.6	4.7	5.8
Snowmobiles (TH)	0	2	1600
Commercial Aircraft (Turbofan)	0	202	1989
Private Aircraft (TH)	45	76.2	136
Outdoor Appliances (Approximate)			
Lawn Mowers (M)		10	17
Chain Saws (M)		.5	1.2
Home Appliances	1953	1960	1970
Dishwashers (M)	1.3	3.2	14.9
Clothes Washers (M)	32.2	42.0	57.6
Clothes Dryers (M)	1.5	9.0	25.3
Air Conditioners (M)	0.6	6.5	23.0
Food Mixers (M)	12.6	27.0	51.2
Food Waste Disposers (M)	1.4	4.8	14.4

*Based on EPA Reports by Wyle Laboratories (4) and Bolt Beranek and Newman (7).

The next sections of the report will deal with the effects of noise, starting with the medical ones.

3. Effects of Noise

3.1 Medical

Since the most extreme and widely recognized effects of noise are concerned with deafness, the medical aspects of noise will be covered first. It is difficult to make any definitive statement about the number of people in our country suffering from either partial or total deafness because there are conflicting estimates. A recent estimate was made by Dr. R. Marcus (8) at the EPA Hearings in Chicago:

Hearing Loss -- By Age

Age Range	Population Totals (in thousands)	Loss of Hearing Totals (thousands)	Noise-Associated Hearing loss (thousands)
0-5	17,000	850	?
5-10	20,000	1,000-1,400	*200
10-18	32,500	650- 975	**150
18-65	113,000	2,260	2,000 (Approx)
over 65	20,000	4,000	400-600
TOTALS	202,500	8,760-11,135	2,750-2,950

*Most common cause is explosions from toy caps (20% sensory-neural hearing loss).

**Firearms and toy caps (based on approximately 20% sensory-neural).

Although the occupational noise exposure regulations promulgated under the Occupational Safety and Health Act are designed to control noise exposure within the work environment, this continues to be a major problem area. Dr. A. Cohen (9) recently reported that the total number of United States workers experiencing noise conditions potentially hazardous to hearing is estimated to be in excess of six million and may be as high as sixteen million. It is now becoming evident that many occupations are included among those in which noise is a hazard. In addition to the heavy industries traditionally associated with this problem, construction workers, textile employees, truck drivers and pilots of both fixed and rotary wing aircraft are included. The new computer-based organizations are not immune to this hazard either. Keypunch and paper tape devices and equipment such as the optical character recognition and letter-sorting machines used in post offices all produce noise that may ultimately affect their operators as well as others working nearby.

It is estimated that more than 10 million operators of heavy trucks, motorcycles and gas engine powered recreational vehicles are currently being exposed to noise at excessive levels. An additional major source of noise exposure is the home workshop. There are approximately 12 million home workshop tools in use in the country, many of which are major noise sources not only to the operators and other family members but sometimes to neighbors as well.

Dr. D. Lipscomb (10) has reported a number of findings associated with recent trends in hearing loss. For several years many investigators have expressed concern about the possible adverse consequences caused by music heard at greatly amplified sound levels. Dr. Lipscomb indicated that entering freshmen college students did have hearing disorders that were attributed to exposure to music played at very intense levels. A series of audiometric tests were given to more than seven thousand students ranging from sixth graders to college freshmen. The findings indicate a steady increase in hearing loss at high frequencies, as measured by a screening examination. While only 3.8% of the sixth graders failed this test, the comparable figure was approximately 10% for 9th and 10th graders and was more than 30% for incoming college freshmen. Examination of the next freshmen class (Fall 1969) yielded the most disturbing findings of all, 61% of them failed the audiometric "screening" test. Dr. Lipscomb concludes that the data presented are a cause for concern. There is evidence that the hearing acuity of young persons 21 years of age and under is becoming reduced many years before one would expect such reductions. These implications lead to the fearful speculation that the current population of young persons will encounter much more serious hearing problems in their middle years than the present group of 50 to 60 years olds.

Even the strictly medical consequences of noise cannot be limited to auditory effects. Many investigators have documented physiological changes associated with noise, whether subjects were awake or asleep. It is hypothesized that there may be cardiac, vascular, neural or other effects which bear directly on the overall health of people. Dr. G. Jansen (11) found that "Blood circulation does not adapt to continuing exposure to noise by a return of blood flow to its initial level. Instead, peripheral blood flow continues to be reduced as a result of continuing vaso-constriction and increased resistance. This phenomenon was first observed at about 60 to 70 dB and as sound intensity increased, it became more pronounced". N. N. Shatalov (12), a Russian scientist, studied 589 factory workers in a number of industrial plants. He found that the effects were different for two types of noises. He noted that continuous noises resulted in "arterial tension, downward trend in venous pressure, reduced peripheral resistance and bradycardia". Intermittent noise on the other hand caused "hypertension, rising arterial pressure and frequent capillary spasms". Miss Alice Suter (13) of the National Association of Hearing and Speech Agencies made the following statement at the recent EPA-sponsored hearings in Atlanta: "The process of vascular constriction keeps on going and does not adapt, and it also limits the blood supply to the ear. Lack of proper blood supply over years would definitely be a contributing factor to old age hearing loss. The internal auditory artery which leads to the ear is the smallest artery in the body, and it is probably quite apt to suffer vascular constriction". Dr. L. E. Farr (14) summarized his views on the effects of noise in the following way: "In disease states such as anxieties, duodenal ulcers, and other so-called tension ills, the additive deleterious effect of noise is real and immediate. Any disease which may be associated with an emotional change requires as part of the therapy a calm, relaxed, quiet environment. This is particularly true of disturbed emotional states."

It might be conjectured that among those people not in peak physical condition (aged, disabled and convalescent) noise is an impediment to rest and can thereby contribute to longer convalescent periods and lower general levels of activity often associated with fatigue and loss of sleep.

Although the findings cited above are merely typical of many studies indicating the non-auditory effects of hearing, it should be made clear that many researchers are not convinced of their relevance to any real medical problem. The lack of any clearcut link between these physiological indices and adverse medical consequences has been the primary reason for such judgments. In answer to this attitude, the aforementioned Dr. G. Jansen notes that "Experimental work and field studies concerned with disease other than occupational deafness must assume -- until the contrary is proved -- that noise can be harmful".

Perhaps one of the most important factors in assessing the medical impact of noise is the fact that its effects are cumulative. When thinking of the noise experienced during the course of a day, from day to day and over the course of a lifetime, an interesting perspective emerges. Millions of workers are now being exposed to industrial noises that are expected to produce permanent hearing defects. Many millions of other workers experience noises barely below the maximum levels promulgated under the authority of the Occupational Safety and Health Act. But these same workers do not enjoy quiet during their non-working hours. On the contrary, they are exposed to transportation noises while commuting to their jobs, appliance noises at home and possibly community noise sources as well. An illustration of the "noise history of a typical person" is included below. Since this information is included only for illustrative purposes, there is no attempt to specify age ranges or exposure duration data.

LIFETIME EXPOSURE TO NOISE (ILLUSTRATION)

	Childhood	Youth	Maturity
Cap Pistols	X		
Firearms		X	X
Rock & Roll Music		X	
Transportation			
School Bus	X	X	X
Automobile	X	X	X
Train (subway, elevated)		X	X
Aircraft		X	X
Household Appliances	X	X	X
Construction Equipment	X	X	X
"Community" (roadside, flight path)	X	X	X
Recreational Vehicles		X	X

X = Exposure to noise source

One other direct medical consequence of noise is a possible increase in the accident rate. The authors of the 1963 British Noise Study (16) indicate that "It seems reasonable to suppose that if high noise levels increase, the number of errors during work will also increase. They will also cause errors in safety measures and consequently high noise levels may cause a higher rate of accidents than would occur in quieter conditions." Another possible cause of accident is the masking of an auditory alarm. Since danger signals often take this form, it can be reasonably expected that some such signals will be masked out in environments typical of heavy industry operations, construction activities and mid-city traffic during shopping and commuting hours.

In view of all of the foregoing, the nature and cost of medical services might be expected to be profoundly altered, not merely for those directly affected but for our society as a whole, if the number of persons seriously affected by noise significantly increases. A greater proportion of every dollar devoted to medical treatment would have to be set aside to treat hearing disorders. If the findings indicated in the studies by Dr. Lipscomb are substantiated by others, many people would spend their adult lives as partially handicapped individuals requiring medical attention as well as prosthetic devices to improve their hearing. The societal costs associated with an increase in deafness in the population would result in educational, job related, and medical consequences. Resources projected for use in combatting heart disease, cancer, nervous disorders and other diseases might have to be directed to auditory research. The medical profession's capability to treat auditory disorders might have to be upgraded by means of additional facilities and training grants. Overall payments for medical services, and therefore insurance rates, would be expected to increase to cope with a rise in the incidence of partial and total deafness. Finally, since relatively normal hearing is a pre-requisite for many jobs (e.g. answering a telephone), many people could find that loss of hearing has reduced the number and type of available job opportunities.

While examining the effects of noise on people and groups, it is easy to lose sight of an evident but important fact. The "average" person or group simply does not exist. It should be noted that responses to noise by individuals as well as by classes of people differ markedly.

The reaction of groups, and communities of individuals, arise in part from the aggregation of personalized responses of individuals, and from their interaction with a wide variety of sociological influences. As an example, due to ethnic background one group of families may accept a noisy environment in their home life situation which would be considered as unacceptable to those of different cultural orientation. They may in fact create conditions which while acceptable to themselves are considered "noisy" by others.

This phenomena must be taken into account in assessing the attributes of noise as a sociological problem. It also must be given careful attention in translating results of various studies on noise as relates to a particular source, and affecting a specific population (such as the variously cited ones on transportation noise mentioned elsewhere in this section and in other portions of this report) to other sources, situations or populations. This caution was cited in Karl Kryter's recent work "The Effects of Noise on Man" (15) in relation to possible nationalistic differences in tolerance to road noise. He further discusses the many factors in this regard which must be taken into account in assessing validity of various studies and study techniques.

3.1 Psychological

A segment of the population (estimated from 2% to 10% depending upon the source) is considered to be highly susceptible to noise at almost any level while some individuals (possibly 20% of the population) barely respond to noises considered quite intense by others. Borsky (17), cited the following factors found to be most important in enhancing or impeding noise acceptability: (1) feeling about the necessity or preventability of the noise; (2) feeling of the importance of the noise source and the value of its primary functions; (3) types of living activities affected; (4) extent to which there are other things disliked in the residential environment. Parrack (18), in an evaluation of community response to noise, provided data on the characteristics of people more likely to complain about noise. He noted that they were generally of higher socioeconomic status, had more education and were likely to have political affiliations. Mr. J. Van Den Eijk (19), in describing the new Dutch code on noise control, noted a similar relationship between "nuisance" complaints, social status and education. He also found that those people engaging in mental, as contrasted to physical, occupational pursuits were more likely to complain about noise. This latter finding is consistent with that of the London noise survey and many others. A recently completed NASA study (19) concerned with community response to noise indicated that on the average, complainants are older, more affluent and have a higher education level than non-complainers.

A close relationship between expressed annoyance and level of noise intensity was pointed out almost 15 years ago by Parrack (17). He reported the results of community surveys based on 3500 people in widely separated areas. In general, the number of people expressing annoyance increased steadily as the noise level increased. He also found that the number of complaints were a good indicator of the degree of annoyance. The English study of noise around Heathrow Airport indicated that 22% of

the respondents said they were sometimes kept from going to sleep due to aircraft noise. This figure rose to 50% with an increase in noise levels. A still greater proportion, also increasing with a corresponding increase in noise level, complained of being awakened by noise. A Swedish (21) traffice noise survey indicated that the proportion of people annoyed increased linearly with increasing noise levels from 50 dBA on, based on a 24 hour average. Symptoms such as headache, insomnia and nervousness were closely correlated with annoyance measures of the severity of exposure.

The studies by Parrack and the London Noise Survey are typical of many investigations which demonstrated that nighttime sounds are more annoying than daytime sounds. H. A. Denzel (22) indicates that: "We know that noise interferes with rest and relaxation and especially with sleep. While sleep, the complete withdrawal from the world around us, is an obvious necessity for physical and emotional health, less complete withdrawal into the quiet of our homes may also be necessary if we want to retain individual integrity."

Many researchers concerned with noise are convinced that noise levels that are not intense enough to cause permanent damage cannot simply be dismissed as a nuisance which is a necessary waste product of technological progress. The reasons for this widespread interpretation are partially rooted in the characteristics of sound and the types of effects associated with noise. Experimental findings have consistently demonstrated that when visual and auditory signals are concurrently presented, subjects tend to respond to the auditory signals first, presumably because of some "attention demanding" quality. Researchers designing warning devices have made use of this characteristic for years. Another characteristic of noise that causes annoyance is that it affects people who are in the position of "innocent bystanders". That is, in many instances those people responsible for producing noise are not the same ones who are severely affected by it. Also the receivers of the noise in those instances have no control of the noise source. Borsky (17) indicates that annoyance is closely associated with the degree to which the noise producer is concerned with and doing something to minimize the effect of noise on the receivers of the noise. As further evidence of this effect, D. C. Glass, et al. (23) conducted a study which indicated that subjects showed lowered tolerance for frustration after exposure to unpredictable noise. In a later experiment, when the noise source was under the control of the subjects, these frustration effects were significantly reduced. This aspect of the problem is very important because it has been repeatedly demonstrated that when there is no benefit to a person associated with an activity and yet there are adverse consequences that must be suffered, there is very little tolerance for these consequences. For example, if two people live near a highway and one uses it for commuting while the other one walks to work, the walker is much more likely to complain about noise and air pollution due to automobiles than is the person who drives (all other things being equal).

The pervasiveness of noise, combined with these characteristics already noted, makes it a problem of special concern when psychological well-being is considered. The human organism being driven at a frenetic pace in the modern word is the same one that evolved to cope with the more leisurely pace of the past. Most competent medical practitioners, as well as researchers, agree that there is an absolute requirement for rest and recreational activities at regular intervals in order to maintain adequate mental and physical health. It is evident, when we consider the quality of life, that the need becomes an overriding one. Where is the needed place of refuge in our modern society?

The home has traditionally served the function of providing a haven for the individual and the family. Ironically, in the case of noise, the characteristics associated with a haven are subverted in two major ways, the "outside world" cannot be shut out and the "inside world" cannot be confined within.

In considering noise within the home, it is useful to make the distinction between single-family dwellings and other houses. In multiple-family buildings, the lack of acoustical privacy is a major source of difficulty. Acoustical privacy can be defined as the expectation that sounds generated within one household will not be broadcast to other households throughout the building. This particular problem deserves attention because of the slowly evolving changes in construction techniques. There is a trend toward using lightweight construction materials that have relatively poor sound insulating properties. If this trend continues (without modification of the sound insulating properties), the future homes will have far less acoustical privacy than did the past homes. Privacy, as annoyance, has been a difficult concept for researchers to contend with in an objective fashion. The authors of the London Noise Study equated the two somewhat by indicating that annoyance due to noise may be thought of essentially as the resentment we feel at an intrusion into the physical privacy we have. The existence of the problem, though, has been documented in a variety of community studies conducted in this country and abroad.

Noises in the home can be generally categorized into three sources: those generated by family members, building noises (fans, blowers) and those originating outside but penetrating the home. The mechanical "helpers" within the home are a major source of complaint by householders. Although washers, dryers, garbage disposer units, etc., have made household tasks easier to physically perform, they have exacted a psychological cost. The relatively long cycle time of many of these devices has not resulted merely in a noise nuisance but in a persistent one as well. Although the family benefits from the primary noise sources within the home, even those noises are a source of conflict among family members engaging in incompatible activities, e.g., the housewife washing the supper dishes and the husband reading the newspaper or watching TV.

The community noise studies already cited are in substantial agreement that noise seriously affects many of the activities often engaged in at home. The British study indicated that noises in the home outnumbered all other disturbances. Rest and relaxation are difficult, and there is interference with TV viewing, listening to music, reading, conversation, and many other social and recreational activities. These and other investigations indicate that the home appears to be the focal point for a great number of noise sources in the community. Among the major causes of complaint, the following have been cited most frequently: traffic, aircraft, industrial plants, construction, and neighborhood related sources such as dogs and power lawn mowers.

When rest and recreation cannot be successfully accomplished at home there is a tendency for people to seek these diversions elsewhere. This has been one of several factors leading to an intensive use of the outdoors which has resulted in large recreational industries based on camping, fishing, boating and skiing. The function performed by recreation is primarily that of "unwinding" and relaxing, as a necessary counterpoint to the often hectic day-to-day work and homemaking activities. Since the goal is identified basically with getting away from the usual annoyances, any interference with the achievement of this objective is not well tolerated. Disturbances that are normally considered relatively minor thereby result in a sense of frustration well beyond that normally occurring.

Interference by noise with outdoor recreational activities is almost a universal phenomenon in that it occurs regardless of the time of day and in all seasons of the year. Winter vacations are now being disrupted since the advent of the snowmobile in the same way that motorboats have upset the tranquility of many of our lakes and rivers. The simple enjoyment of nature by hikers and families enjoying picnics is often interrupted by transportation noises generated by nearby roadways or aircraft.

During the recently conducted EPA hearings in Dallas, Mr. T. Berland (24) noted the intrusion of noise in the Fort Parker State Park and Grand Canyon National Park. He indicated that disturbances were caused by jet aircraft, helicopters, snowmobiles, minibikes and motorcycles. Other organizations such as the Sierra Club, have noted that increasing levels of noise are seriously disrupting the serenity of many of the formerly secluded retreat areas.

Outdoor spectator events are also seriously affected by noise, especially aircraft noises. The Watergate concerts in the Washington, D.C., area have for years undergone regular interruptions as a result of overflights associated with nearby National Airport. The enjoyment of the music is made extremely difficult by the almost continuous pattern of takeoffs and landings.

3.3. Social

Professor A. C. McKennell (25) evaluated the results of many community surveys in the following terms: "We know a certain amount about the characteristics of the reactions of communities to events which deeply affect them. A small, middle class group actively protesting in the presence of an apparently indifferent majority is a common occurrence. It is when these active groups gain the support of the larger, normally acquiescent majority, that serious community conflict can result. Under these conditions, what starts as a specific issue often sparks off a more generalized local conflict".

Although the recent conflict over the SST program could hardly be classified as local, all of the other major features cited by McKennell were present with the added feature that individual middle class complaints were institutionalized through many concerned organizations such as the Sierra Club, Citizens for a Quieter City and Citizens Against Noise. The proliferation of these organizations concerned with environmental quality is quite a recent phenomenon. Their successes in defeating the SST and in profoundly altering the methods previously used in prescribing airport and highway design is a matter of almost daily record. The day when planners could concern themselves solely with economic considerations -- sometimes to the detriment of the community at large -- appears to be past.

In a paper entitled "Predicting the Future" (26), Prof. R.A. Bauer of the Harvard Graduate School of Business notes: "if we are moving into a period in which individual citizens increasingly expect to be freed from various forms of environmental nuisance and <u>if</u> citizens groups are tending more and more to take an active role in the decision making process, then it is probable that complaints and effective organized protests will occur at lower levels and frequency rates of noise exposure than in the past". He further stated that, "For a variety of convergent reasons, we appear to be entering a period in which people will be more disposed to organize for direct participation in policy decisions affecting them".

As a counterforce to this community pressure, the industrial community has made use of existing organizations and associations to act in a concerted way in order to minimize the impact of citizens groups concerned with noise. They have indicated that consumers have not been willing to pay for quiet products in the past and that noise reduction is too costly to be borne by the producers alone. Just as the noise producing and receiving <u>organizations</u> have aligned against one another, <u>individuals</u>

often find themselves in conflict because of competing requirements. This situation occurs in the inner city and suburbia, during outdoor recreational activities and at home, whether in multi-family dwellings or in private houses. Whenever one person produces noise while he engages in an activity and thereby disrupts another person requiring quiet for his individual needs, the "battle lines are drawn".

The problem is not new or unique to noise, as the following quote from Spater which appears in "Noise Pollution and the Law", edited by Hildebrand (27) says, "For hundreds of years, indeed throughout most of the history of the common law as we know it, courts have been struggling to reconcile the conflicting interests of two property owners -- one who believes that his ownership entitles him to use his property as he wills and the neighbor who believes that his ownership entitles him to enjoy his property without annoyance. Two major principles have envolved:

First, each person must put up with a certain amount of annoyance. Second, the gravity of the harm to the complainant should be weighed against the utility of the conduct of his troublesome neighbor. The first of these tells us what every city dweller experiences every day of his life. The second is less easy to understand. In determining the utility of the defendant's conduct one must consider in addition to the social value of his conduct, its suitability and the impracticability of preventing or avoiding the annoyance!

Group actions have been but one method of controlling the effects of noise in the community. Laws specifying acceptable limits of noise have been passed at all levels of government. These laws have one factor in common. They were enacted to deal with a specific set of conditions and designed to meet local needs. This has resulted in requirements that differ greatly from community to community, state to state, etc. A continuation of this approach in the future may result in serious disruptions of the economic base in some areas of the country. A non-uniformity of regulations may lead to the movement of noise producing activities to areas where stringent noise regulations are not applied. The introduction of major industrial plants in areas formerly zoned for farm and residential land use has resulted in widespread dislocations in the past where residential areas have become less desirable "overnight", partially due to noise-associated difficulties. Since the presence of industry often requires additional transportation facilities (road, rail and aircraft in some instances) noise is introduced in the area in several ways.

Regulations have been developed with two major goals in mind -- to reduce the incidence of noise-induced deafness and to minimize noise disturbances in the community. The hearing conservation regulations issued under the Federal Occupational Safety and Health Act (OSHA) were designed to combat the problem of industrially associated deafness. At the local level of government, many cities have enacted ordinances to reduce motor vehicle and aircraft noise. Many cities regulate noises produced at construction sites. Another method of noise control at the municipal level is the establishment of requirements for acoustical treatment of buildings.

Private legal actions by citizens have also been an increasingly used method to combat noise encroachments. People have recovered damages when it has been possible to demonstrate a substantial interference with the use and enjoyment of one's property. The usual measure of damage is the decrease in value of the property.

Planners have suggested a number of solutions to reduce the noise impact on the community by separating the noise producers from the noise receivers. In theory, the approach has a great deal of merit, but the results are often mixed. An example is the construction of new major airports to areas distant from concentration of population. Dulles Airport (Washington, D. C. area) was designed with this principle in mind. Unfortunately, economic and social pressures are tending to offset the merits of the plan. The presence of the airport has led to industrial activity nearby and the creation of many new jobs. The people working at and near the airport desire to live at locations convenient to their jobs. Builders, in meeting this need, are pressing for zoning changes to enable the construction of homes in areas where noise levels are known to preclude a satisfactory home environment. In this (and many other instances) the people have moved from a quieter area to the vicinity of a major noise source.

Another method employed in communities has been to strictly limit the use of individual vehicles, thereby facilitating movement of public and commercial transportation. In this instance, noise is but one of several reasons for instituting control measures. However, it is often helpful to think of noise not as an isolated problem, but rather as part of a complex environment, physical as well as psychological. A midcity area is often characterized by crowded conditions, air pollution, crime, as well as intense noise levels. These conditions may well produce a synergistic effect, with noise contributing substantially toward making the environment intolerable because of its omnipresence.

In the context of airport noise, the study of Logan Airport (6) indicated the nature of the dilemma often faced by planners. They note that a successful program to alleviate community conflicts requires long range planning that considers the needs not only of the airports, but of the surrounding community.

In the continued absence of effective noise control programs, the problems associated with noise that are now experienced can be expected to increase. The trend toward increasing mechanization makes the increase in number and variety of noise sources all but inevitable. If past experience can be used as a guide, it can be anticipated that an increase in noise levels will result in an increasing tendency for individuals and groups to promote regulation of noise by legislative means. Since noise extends into many aspects of our society, its regulation might be expected to take a number of forms and have rather broad effects.

Thus far we have considered basically the middle class reaction to the noise problem. Generally, the tendency has been, as expected, to work directly through the traditional political process to effect environmental change. However, the findings of many research studies may also indicate the response of the disadvantaged people in society. Parrack, Borsky, and other researchers note that annoyance produced by noise is closely related to the attitude of people to their general living environment. Borsky (17) notes that it has been found that the more a person dislikes other things about his community, the more hostile he may be to a noise interference, especially if he feels powerless to change other environmental disturbances and if the noise is a more recent addition to his cumulative dissatisfaction. Isn't it reasonable to assume that "the poor" are under-represented in these statistics because of their past experience in dealing with governmental institutions? Unfortunately, in the recent past community protests registered by the poor have taken a very direct and violent form. Might not increasing levels of noise contribute to this type of action again in the future?

Since control of the source of noise has been determined by acousticians to be an effective approach in noise reduction, a good deal of activity may be expected to accomplish this goal. While the aircraft industry has for many years been concerned with this problem, as associated with community noise primarily, many other industries are likely to receive increased attention. The other transportation industries (automobile, railroads) have already been identified as major causes of annoyance due to noise in community surveys. These surveys have also resulted in the increasing attention which is now given to construction equipment, powered "pleasure" vehicles and household appliances. The establishment of noise standards may be expected to have similar consequences to those following the formulation of safety standards, i.e., higher costs to the producer which are passed on to the consumer. In some instances, the availability of low priced items might be curtailed because it would not be economic to quiet them, thereby depriving those least able to pay of needed products. Another area where the poorer

members of our society might be seriously affected is the home. As noted earlier, the lightweight construction techniques now used by many builders have resulted in homes which are said to lack sufficient privacy. If housing codes are developed which reflect this concern for privacy and protection from "outside noise", construction costs are likely to "follow the same path" noted previously, namely that the user will pay for increased acoustical treatment. Since many people now have difficulties meeting payments required for shelter, it can be anticipated that they will be even less able to pay for homes "designed for quiet". Of course, the effects of strong building codes in the area of acoustics will have the most important direct effect upon the builders who are to meet these requirements. In order to meet noise acceptability criteria, some of the techniques used in lightweight construction today may have to be modified. If this were to occur, it might be conjectured that there would be a slowing down of the process of meeting the Nation's stated housing goals.

One major segment of our society has not yet been considered although it plays a major noise role, both as a source and a receiver -- the military. The military provides a microcosm of society's problems with noise because of its widespread activities associated with the major noise sources of transportation and construction. Naturally these activities effect civilian as well as military personnel and add to the general noise problem -- especially with respect to aircraft noise. It is the only source of sonic booms at present and these have been severely disruptive in many communities (as noted elsewhere). Perhaps the most important and direct link between the military and the overall noise problem is the time spent in service by a large proportion of the adult male population. The noise exposure history of millions of people now includes exposure to powerful weapons, tanks, aircraft, and countless other major noise sources which may contribute significantly to the incidence of partial and total deafness in the future. The Veterans Administration has, in some years, been paying approximately 30 million dollars annually for service connected hearing disabilities.

Among those centers of activity most seriously affected by noise are those centered in public buildings. This point was made by Bolt Beranek and Newman, in their study of Logan Airport (6). They indicate that institutional dwellings often require a greater degree of sound conditioning than residential structures because lower sound levels are required for internal use. The requirements of patients in hospitals and the speech level in schools and churches demand special evaluation in the vicinity of an airport.

Recent studies concerned with aircraft noise in the community of Inglewood, California, provide an example. In the local churches, it was indicated that the conduct of meaningful services was virtually impossible. The effects on several schools were so severe that new schools had to be built to serve the community. Other surveys have indicated that serious disruption of classroom activities has been a major effect of noise. Is it not reasonable to assume that the quality of education is going to suffer even when noise levels are not so great that they cause the closing of schools? Conditions suitable for adequate speech communication are necessary for classroom activities in which disruptions by noise can necessitate the repeating of material, can cause misunderstanding of assignments, and difficulty in concentration on complex subject matter (which is especially susceptible to noise interference).

Public libraries, churches and hospitals located in downtown areas sometimes cannot serve the needs of the community because of noise interference. One solution to the problem has been the movement of institutions to quieter locations away from the center of the city. Unfortunately this approach has been self-defeating because it has separated the users from the institutions designed to serve them. This has occurred because the people continued to live in the same area, requiring added expenses for transportation. Also, the time and difficulty in reaching these places tend to discourage attendance in many instances.

Retail stores have followed the path of public institutions because of problems associated with downtown areas. Certainly noise cannot be considered the primary cause for such displacement but it is reasonable to consider it one of the causes for the movement to shopping centers. Industrial plants and other businesses likewise are moving out of the central cities partly because it is difficult for employees to find satisfactory places to live nearby.

Modern society can, in a sense, be defined in terms of the tasks the citizens are called upon to perform. These tasks are becoming more and more concentrated in "white collar occupations", where the emphasis is on "brain power" rather than brawn. The required "muscle", whether on the job or at home, is supplied by electro-mechanical devices. Laboratory and field investigations indicate that intellectually demanding tasks are more subject to performance decrement and expressions of annoyance than other more physical pursuits.

The mass production cycle, typical of many industries, provides another example of this dilemma. On the production line, any error may become quite costly because of the number of "bad" units which can be produced in a very short span of time. It is therefore necessary to maintain very high standards of quality control. At some point in the control process, an inspector often either closely inspects products or monitors a display which has an error readout. With increased efficiency (more production per unit time) error costs can be expected to increase in a corresponding fashion (if we assume a unit error cost). However, in many instances increased production results in increased noise levels, making the "error detection" process of the inspector still more difficult.

Despite greatly increased activity by government, organized groups and private citizens to combat noise, it is questionable whether the scope of the problem is well understood. These overt activities and compilations of complaint records are the product of a small but influential minority of the population. But, Borsky (7) notes that in studies conducted in Britain and the United States, only 10% of all persons with serious noise problems felt that complaining would have any beneficial results. The actual level of disaffection with noise is therefore difficult to estimate.

Suburban living in some areas is beginning to resemble the life style in the cities, because of the limited use of the outdoors. The Wyle EPA Report (4) notes that in an increasing number of instances, it is no longer possible to engage in conversation at a normal voice level on one's patio because of noise intrusions; therefore the family will tend to spend more time indoors. As noted earlier, the prevalence of major noise sources in outdoor recreational areas is diminishing the enjoyment of many activities associated with restfulness and quiet. This might also serve to induce people to stay at home where they can avoid disturbances. It might be speculated that, taken as a whole, these tendencies are divisive in nature and contribute to make the existing problems in our society even worse. This occurs because they tend to separate and isolate individuals and families in contrast to an expansion of interests and activities usually equated with healthy living.

As demonstrated throughout this report, the assessments of the effects of noise have been based on data from many sources and are presented in a variety of forms. This has resulted in statements (some highly quantitative, others primarily descriptive and often speculative) on such indicators as community responses, physiological and annoyance measures and numbers of people deafened by noises. In dealing with this array of information and opinion it is easy to lose sight of the fact that they all deal with the same problem area and therefore should not be considered independently. Rather, it is extremely important to integrate these diverse findings by means of some unifying concepts. One method of accomplishing this objective might be to focus on the characteristic noted previously, namely the cumulative aspect of noise exposure.

This has already been identified as a major parameter associated with loss of hearing. Isn't it also likely to have important psychological and sociological consequences since its effects are so far ranging and intrude into most activities, especially those requiring concentration or rest? It is a commonly experienced phenomenon that comparatively minor disturbances can often be ignored but once they exceed some threshold level, they destroy concentration and become a major source of nuisance.

The argument is often made that noise is not a major problem because people generally adapt to it. Borsky, in summarizing the results of the Oklahoma City sonic boom studies, indicated that there was a steady increase in the number of people "seriously annoyed" as the tests progressed, despite a massive public relations compaign designed to promote acceptance. (The later booms were louder, however, and this factor may have affected the findings. But since there were no booms during the evenings the results might be accurate or even conservative.) Public reaction to sonic booms caused the military to reroute most of its training flights to sparsely populated areas. Laboratory and field studies by Dr. K. Kryter (15) have generally confirmed the findings of Borsky that widespread public reaction would occur if sonic booms were a part of our everyday environment. Miss Alice Suter (National Association of Hearing and Speech Agencies) noted in her EPA testimony:

"The idea that people become adapted to noise is really a myth. As I mentioned previously, the circulatory system does not adapt. Also, studies have shown that people who work in high noise levels during the day are more rather than less susceptible to aggravation from noise after work. The factory worker is more apt to explode at his noisy children than the man who works in a quiet office."

Dr. Rene Dubos, the distinguished microbiologist, experimental pathologist and authority on the ecology of disease, stressed those two factors in a paper given at a 1966 forum on environmental quality (28). Dr. Dubos stated:

"... Modern man, like his ancestors, can achieve some form of physiological and socio-cultural adjustment to a very wide range of conditions, even when these appear almost incompatible with organic survival. The rapid increase in population during the nineteenth century occurred even though the proletariat was then living under conditions that most of us would find almost unbearable ...

"Because human beings are so likely to become adapted to many undesirable conditions, and because they tend at present to make economic growth the most important criterion of social betterment, it will not be easy to create a climate of opinion favorable to the immense effort needed for the control of environmental threats. Yet it is certain that many environmental factors exert a deleterious influence on important aspects of human life. The reason this danger is largely overlooked is that the damage caused to human life by environmental insults is usually so delayed and indirect that it escapes recognition through the usual analysis of cause--efect relationships.

"... the very fact that man possesses great ability to achieve some form of biological or social adjustment to many different forms of stress is paradoxically a source of danger for his welfare and his future. The danger comes from the fact that it is often difficult to relate the delayed and indirect pathological consequences of environmental damage to their primary cause."

Finally, it seems appropriate to present the views of the former Surgeon General of the United States, Dr. W. H. Stewart. In his keynote address to the 1968 Conference on "Noise as a Public Health Hazard", he states (27):

"Twenty years ago this fall, in the town of Donora, Pennsylvania, a combination of unusual weather conditions and fumes from local factories produced an air pollution episode during which 20 people died and hundreds more were made acutely ill. The same sort of thing had been happening for a number of years, on a larger but less intensive scale in England, Belgium and elsewhere.

"Of course we haven't had our Donora episode in the noise field. Perhaps we never will. More likely, our Donora incidents are occurring day by day, in communities across the Nation -- not in terms of 20 deaths specifically attributable to a surfeit of noise, but in terms of more than 20 ulcers, cardio-vascular problems, psychoses, and neuroses for which the noises of 20th centruy living are a major contributory cause.

"Must we wait until we prove every link in the chain of observation? I stand firmly with Burvey's statement of 10 years ago. In protecting health, absolute proof comes late. To wait for it is to invite disaster or to prolong suffering unnecessarily.

"I submit that those things within man's power to control which impact upon the individual in a negative way, which infringe upon his sense of integrity, and interrupt his pursuit of fulfillment, are hazards to the public health".

References

(1) The Noise Around Us, U. S. Department of Commerce Publication, 1970.

(2) Johnson, C. C., Statement at EPA Hearings, Washington, D. C., 1971.

(3) Our Cities - Their Role in the National Economy, National Resources Committee in a Report for the President, 1937.

(4) Wyle Laboratory Report for EPA, Community Noise, Transportation Noise, and Noise from Equipment Powered by Internal Combustion Engines, NTID 300-3.

(5) Jamaica Bay and Kennedy Airport Environmental Studies Board, National Academy of Science, National Academy of Engineering, 1971.

(6) Bolt Beranek and Newman, Aircraft Noise and Airport Neighbors: A Study of Logan International Airport, DOT/HUD IANAP 70-1, 1970.

(7) Bolt Beranek and Newman Report for EPA, Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances, NTID 300-1.

(8) Marcus, R., EPA Hearings in Atlanta, 1971.

(9) Cohen, A., Noise effects on health, productivity and well being, Transactions of New York Academy of Science, Series II, Volume 30, 1968.

(10) Lipscomb, D., EPA Hearings, Washington, D. C., 1971.

(11) Jansen, G., Effects of noise on health, German Medical Monthly, Volume 13, 1968.

(12) Shatalov, N. N., Some Hemodynamic Changes Provided by Industrial Noise, U. S. Army Intelligence Report, 1965.

(13) Suter, A., EPA Hearings in Atlanta, 1971.

(14) Farr, L. E. , Medical consequences of environmental home noises, Journal of American Medical Association, Volume 202, 1967.

(15) Kryter, K. D., The Effects of Noise on Man, Academic Press, New York, 1970.

(16) Committee on the Problem of Noise, Noise, Her Majesty's Stationary Office, 1963.

(17) Borsky, P. N., Community Reaction to Sonic Booms in the Oklahoma City Area, AMRL Technical Report 65-37, Wright Patterson AFB, Ohio, 1965.

(18) Parrack, H. O., Community Response to Noise, Handbook of Noise Control, Ed. C. Harris, McGraw Hill, New York, N. Y., 1957.

(19) Van Den Eijk, J., The new Dutch code on noise control, Journal of Sound and Vibration, Volume 3, 1966.

(20) Community Reaction to Airport Noise, Tracor Corporation, 1971.

(21) Fog, H., and Johnson, E., Traffic Noise in Residential Areas, National Swedish Institute for Building Health, 1969.

(22) Denzel, H. A., Noise and health, Science, Volume 143, 1964.

(23) Glass, D. C., Singer, J. E., Friedman, L. N., Psychic cost of adaptation to an environmental stressor, Journal of Personality and Social Psychology, Volume 12, 1969.

(24) Berland, T., Testimony in EPA Hearings, Dallas, Texas, 1971.

(25) McKennell, A. C., Complaints and Community Action, in Transportation Noises / A Symposium on Acceptability Criteria, Ed. J. D. Chalupnik, University of Washington Press, Seattle and London, 1970.

(26) McGrath, D. C., City Planning and Noise, Division of Metropolitan Area Analysis, HUD.

(27) Hildebrand, J. L., Noise Pollution and the Law, Law Book Publishers, Buffalo, New York, 1970.

(28) Dubos, R., Man, Medicine and Environment, F. A. Praeger Publishers, New York, N. Y., 1968.

(29) Noise as a Public Health Hazard, American Speech and Hearing Assn., ASHA Report No. 4, 1969.